

**TITLE**

## ELECTRIC MACHINE IMPROVEMENT

**This invention relates to electric machines and in particular to a coil arrangement with respect to an isotropic core.**

## 5 TECHNICAL FIELD

**Electrical machines be these motors, generators or transformers currently conventionally use coils of electrically conductive wire wound around a magnetically inducible laminated core to create or be affected by magnetic fields.**

## BACKGROUND ART

10 Winding of such coils has become a highly developed art but in so far that a coil  
is required there is a need therefore for a compatible shape of core to allow for  
the location of the wound coil around a portion of the core with it is hoped an  
efficient magnetic coupling. Further, in order to reduce eddy current loss's in a  
core, it is also conventional to laminate the core using a plurality of separate  
15 plates or laminations which are laid against one another with the alignment of  
each lamination being determined by the overall structure of the electric machine  
and where any magnetic fields induced therein are required to be directed. This  
required structure however which is to say wound coils and laminated cores  
currently determine the current conventional electric motor construction  
20 requirements.

## DISCLOSURE OF THE INVENTION

I have discovered that there can be an alternative construction which I have found can provide alternative options for electric machine designers which does in at least some cases provide advantages over the current machines designed according to current techniques.

Other objects and advantages of the present invention will become apparent from the following description taken in connection with the accompanying drawings wherein by way of illustration and example an embodiment of the present invention is disclosed.

Figure 5A is a cross-sectional view of a stator of an electrical machine constructed according to a preferred embodiment of the present invention, and

Figure 6 is a fragmentary cross sectional view of the stator of Figure 2, with the conductors shown.

## 5 BEST MODE FOR CARRYING OUT THE INVENTION

Now referring to illustrations and particular to Figure 1 which is a cross-sectional view of an electrical machine offered in prior art. There is a stator core 1 surrounding a rotor cavity 2.

10 Wound around the stator core 1 in conventional fashion are coils of insulated copper wire. The coils have a winding fill factor of typically 40%-60% with open slots to facilitate coil entry. The winding of these coils results in a substantial part of the coil extending beyond the stator. These extents are end windings 4. These windings minimally contribute to the working of an electric machine.

15 Figure 2 shows a stator of an electric machine in accordance with an embodiment of this invention. There is provided a stator 5 in a form of an annular cylinder of soft magnetic composite material in this case somalloy. This is an isotropic material. Its electrical and magnetic properties are substantially direction independent. A rotor will fit into rotor cavity 3.

20 At each end of the stator 5 there is provided a stack of three printed circuit boards 7 which are each positioned to overly each other and to also be parallel to each other and which each act as bridging members to electrically complete an coil like arrangement through the stator 5. This stack of printed circuit boards 7 can be seen more clearly in Figure 5. This stack of printed circuit boards could be realised as a single multi-layer printed circuit board.

25 The use of the bridging members reduces the non-contributing conductive pull outside the stator to only the thickness of the bridging members, as shown in Figure 5. This may be further reduced by shaping the stator 5 around the bridging members as shown in Figure 5A.

As can be seen in figure 3 each board has a series of tracks 8 printed thereon

which selectively connect wire solder points 9. The stator 5 has a plurality of bores 13 drilled longitudinally and parallel one to the other through it in a pattern corresponding to the position of these wire solder points.

Each of these bores has an enamel insulated wire inserted therein. The  
5 diameter of the bore and the wires is such as to provide a loose sliding fit. Fill factors of approximately 90% may be achieved.

The wires are then selectively soldered and thereby electrically connected to one of the three printed circuit boards at one end and to a corresponding one of the three printed circuit boards at the other end.

10 As can be seen the top and bottom printed circuit boards are provided in pairs each pair forming one coil. In this case there are three coil sets which is the most common number of coils provided for a brushless DC electric motor. However it would be possible to provide more or less pairs of printed circuit boards in order to provide more or less coils.

15 This can most clearly be seen in Figure 5 where the three pairs of printed circuit boards 10, 11 and 12 are shown. The wires are omitted for clarity but it is possible to see the bores 13 in which they are inserted.

In Figure 5A, the conductors 20 are shown.

Referring to Figure 4 it can be seen that there are groups of solder points 15  
20 which are available to the connected by tracks on this printed circuit board. It can be also seen that there are two further groups of holes 16 and 17 through which the coil forming wires pass in order to arise at other of the printed circuit board for connection thereto.

The full set of three printed circuit boards provided at one end of the stator  
25 consists of three boards as shown in Figure 4 rotationally offset by 120°. The connection of the conductors can be seen in figure 6. The stator 60 is pierced by a plurality of long, parallel bores 68. Three such are illustrated containing respective conductors 64, 65 and 66. The bores and conductors are not shown to scale. In a practical embodiment the conductors would almost fill the bores to  
30 give a high fill factor. These conductors emerge from the top of stator to meet

- three printed circuit boards 61, 62 and 63. Respective conductors are brought into electrical contact with conducting tracks on respective boards by solder joints 69. It can be seen that conductor 64 is connected to board 63, conductor 65 to board 62 and conductor 66 to board 61. This arrangement is repeated at the bottom of the stator, with three further printed circuit boards. Further connections (not shown) are made to further conductors such that each pair of bottom and top printed circuit boards (pairs of boards 10, 11 and 12 in Figure 5) and associated conductors forms a continuous conducting path enclosing part of the stator material 60.
- 10 The result of this arrangement is that by using traditional electrical conductor joining techniques such as solder the manufacture of an electric machine can be somewhat more economical than has been the case hitherto and also with the arrangement of individual wires being separately located in individual bores allows a machine designer to allow for advantageous ratings in many cases that
- 15 mean there can be very good economic advantages.

The purpose of this description is to describe the invention and not to limit this.

## CLAIMS

1. An electric machine which includes a magnetically inducible core of a substantially isotropic material and at least three individual elongated electrical current conductors passing through for each a respective through bore through the core with a first end of a first conductor being at a first side of the core and a first end of a second conductor being at the same said first side of the core, the two respective first ends being electrically connected together by a bridging member, and a second end of the second conductor is at a second side of the core and a first end of a third conductor is at the first side of the core, and a second end of the third conductor is at the second side of the core, the two respective second ends being electrically connected together by a bridging member, each bridging member being adapted to electrically connect the plurality of conductors in pairs such that a single continuous electrically conductive path is formed, running through the core through a plurality of bores.
2. An electric machine as in claim 1 including a plurality of elongate electrical current conductors passing through for each a respective bore and two separate bridging members at the first side of the core wherein a first two of the conductors are connected electrically together by a said first of the bridging members and a said second two of the conductors are connected together electrically by a second of the bridging members, and with a first end of a each conductor being at a first side of the core and a second end of each conductor being at a second side of the core, and at least two bridging members at each side of the core, wherein each bridging member is adapted to electrically connect the plurality of conductors in pairs such that at least two separate continuous electrically conductive paths are formed, each running through the core through a plurality of bores.
3. An electric machine as in claim 2 wherein each of the separate electrically conductive paths is connected to a different phase of a multi-phase electrical supply.
4. An electric machine as in any one of the preceding claims wherein the



10

bridging member is a printed circuit board.

- 5
5. An electric machine as in any one of the preceding claims wherein the core is comprised of a soft magnetic composite material.
6. An electric machine as in any one of the preceding claims wherein the core is comprised of high resistance bonded iron.
- 10
7. An electric machine as in any one of the preceding claims wherein each of the electrical current conductors has an electrically insulating coating located so as to extend around its outer side at least where it is in an adjacent or adjoining relationship with the inner surface of the bore through which it is located.
8. An electric machine as in any one of the preceding claims wherein the insulation is an enamel coating.
- 15
9. An electric machine as in any one of the preceding claims wherein each of the elongate electrical current conductors is located within a smooth-sided bore passing fully through the core and is of a matching cross-sectional shape and size such that the inner dimensions of the bore are close to external dimensions of the outer surface of the elongate electrical conductor.
- 20
10. An electric machine as in any one of the preceding claims wherein the fill factor of the windings within the stator is greater than 85%.
11. An electric machine as in any one of the preceding claims wherein the bore is coated with an insulating lacquer.
- 25
12. An electric machine as in any one of the preceding claims wherein any or each of the conductors may pass through one or more of the bridging members without electrical contact thereto such that there are independent electrical contacts with respective electrical circuits.

13. An electric machine as in any one of the preceding claims wherein the electric machine is an electrical motor.
14. An electric machine as in any one of the preceding claims wherein the electric machine is an electrical generator.
- 5 15. An electric machine as in any one of the preceding claims wherein the electric machine is an electrical transformer.
16. An electric machine as in any one of the preceding claims wherein the electrical machine is a brushless generator or motor wherein the core is arranged to be a stator of the generator or motor.
- 10 17. An electric machine as in any one of the preceding claims wherein the elongate electrical conductor is in each case a wire having an enamel outer insulating coating.
- 15 18. An electric motor having a stator which has an isotropic core of a soft magnetic composite material and where there are a plurality of bores passing through the core material and where there is for each of the bores a straight electrical conductor having an outer insulating coating passing fully through its respective bore with a close outer dimensional fit and there being at each end of the electrical conductor a bridging member which is for each respective end connected to other electric conductors.
- 20 19. A method of constructing an electric machine which includes the steps of passing at least two electrically insulated wires or other elongate conductors through a respective one of at least two bores which pass through a magnetically inducible core, and at least at one of the ends of each conductor are connected together by a bridging member.
- 25 20. An electrical machine substantially as described in the specification with reference to and as illustrated by any one or more of the accompanying drawings.

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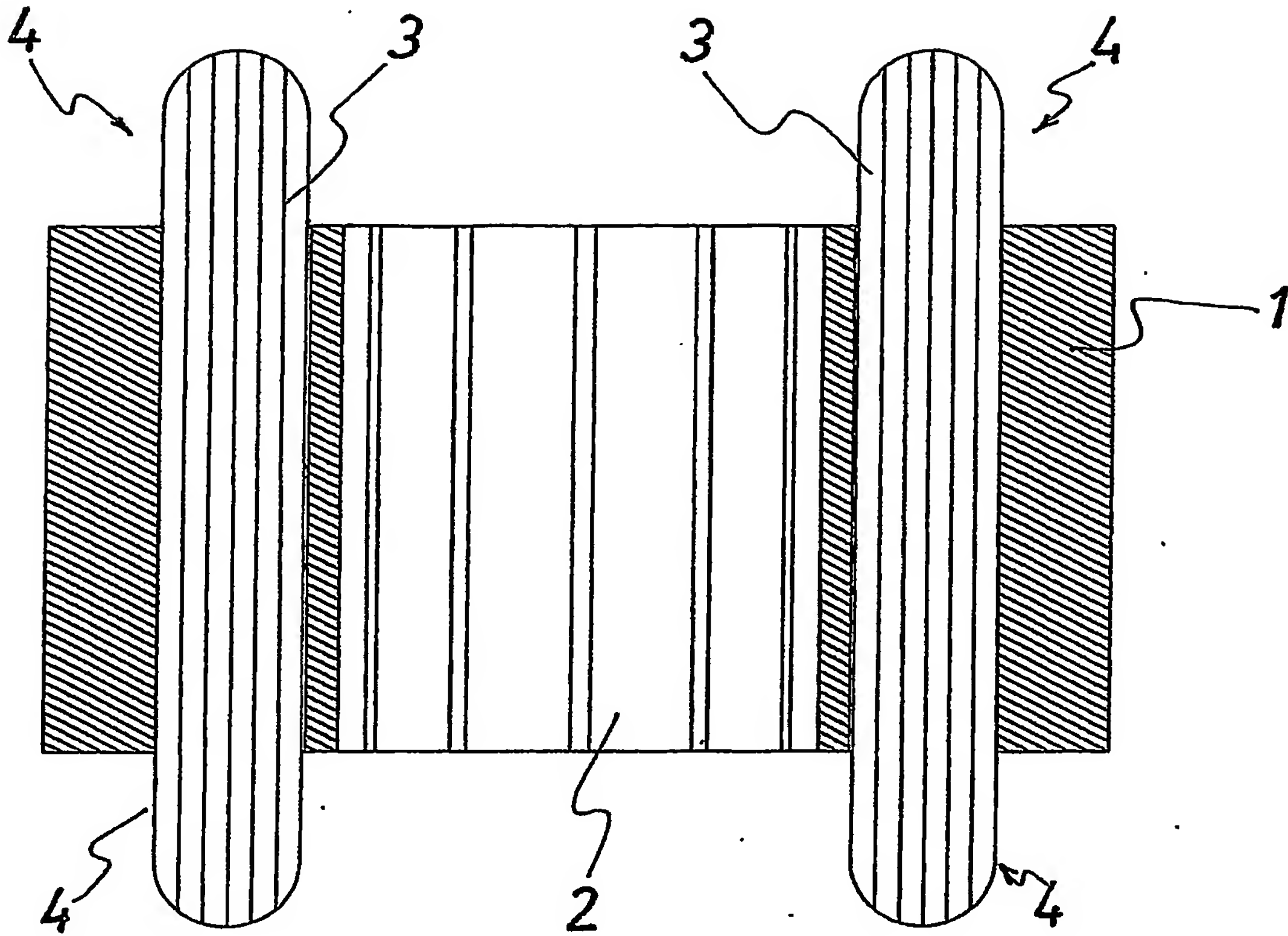
21. A method of constructing an electric machine substantially as described in the specification with reference to and as illustrated by any one or more of the accompanying drawings.

Dated this 24<sup>th</sup> day of October 2005

5 INTELLIGENT ELECTRIC MOTOR SOLUTIONS PTY LTD  
By their Patent Attorneys  
COLLISON & CO

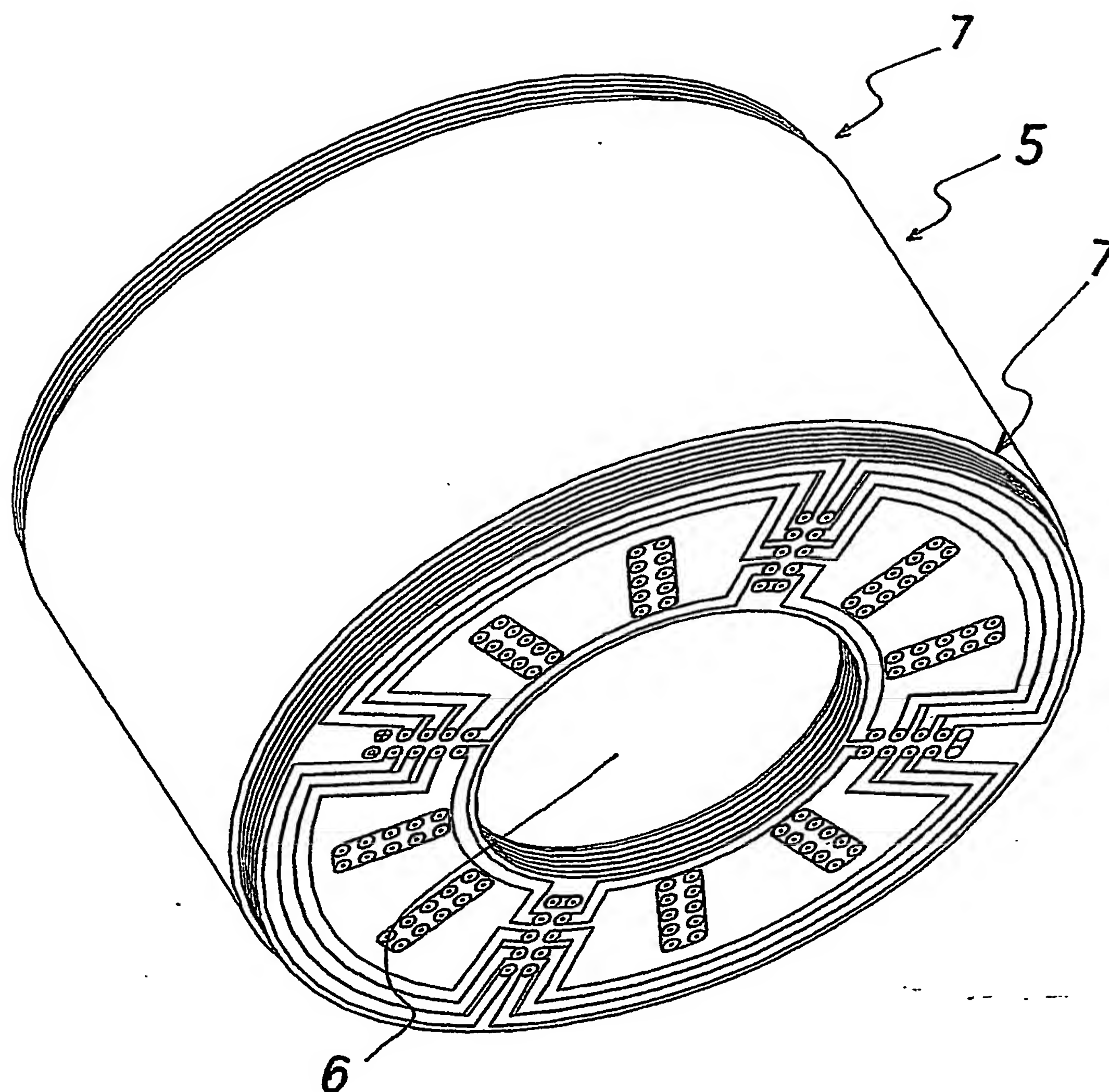


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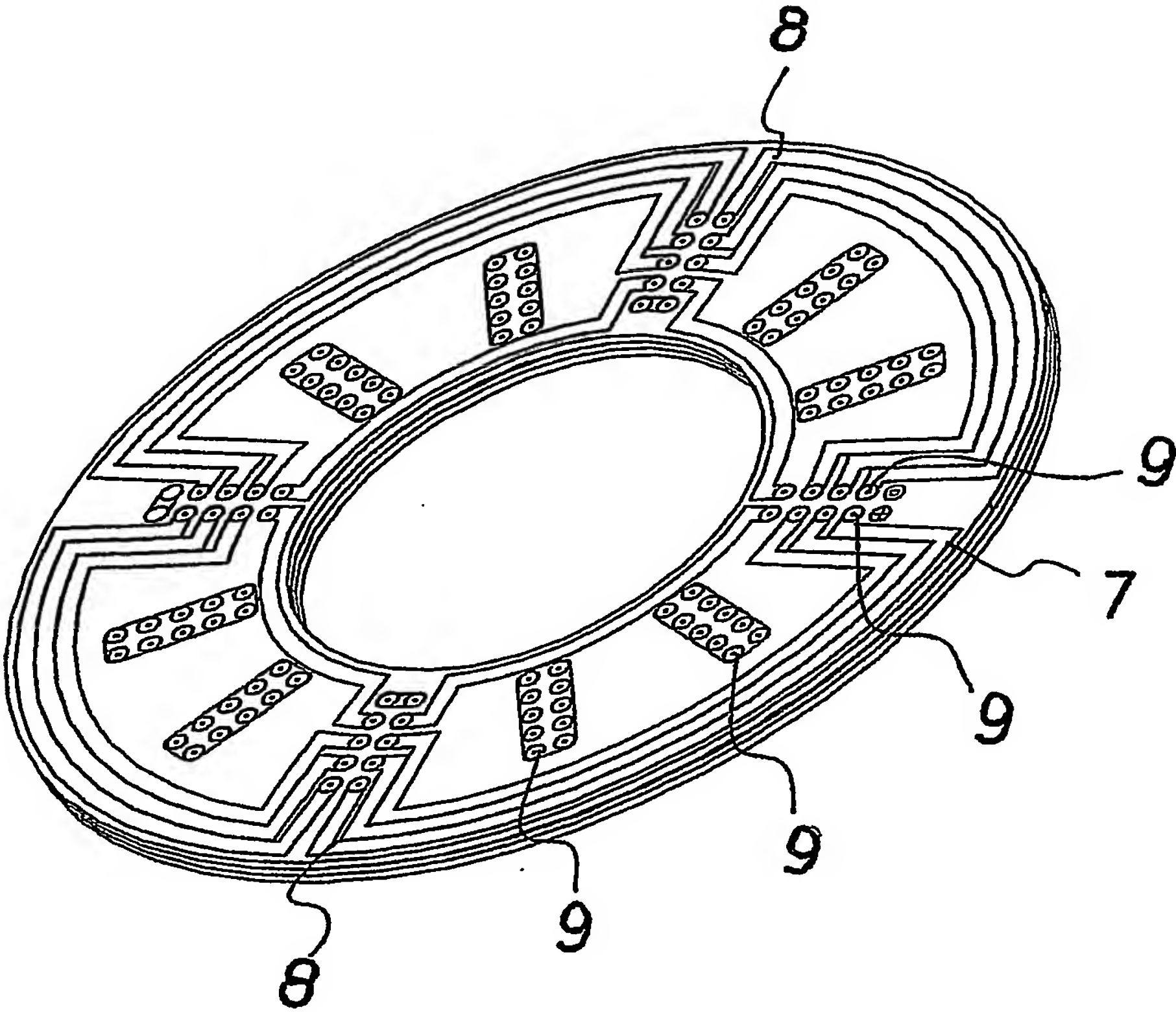
**Fig 1**

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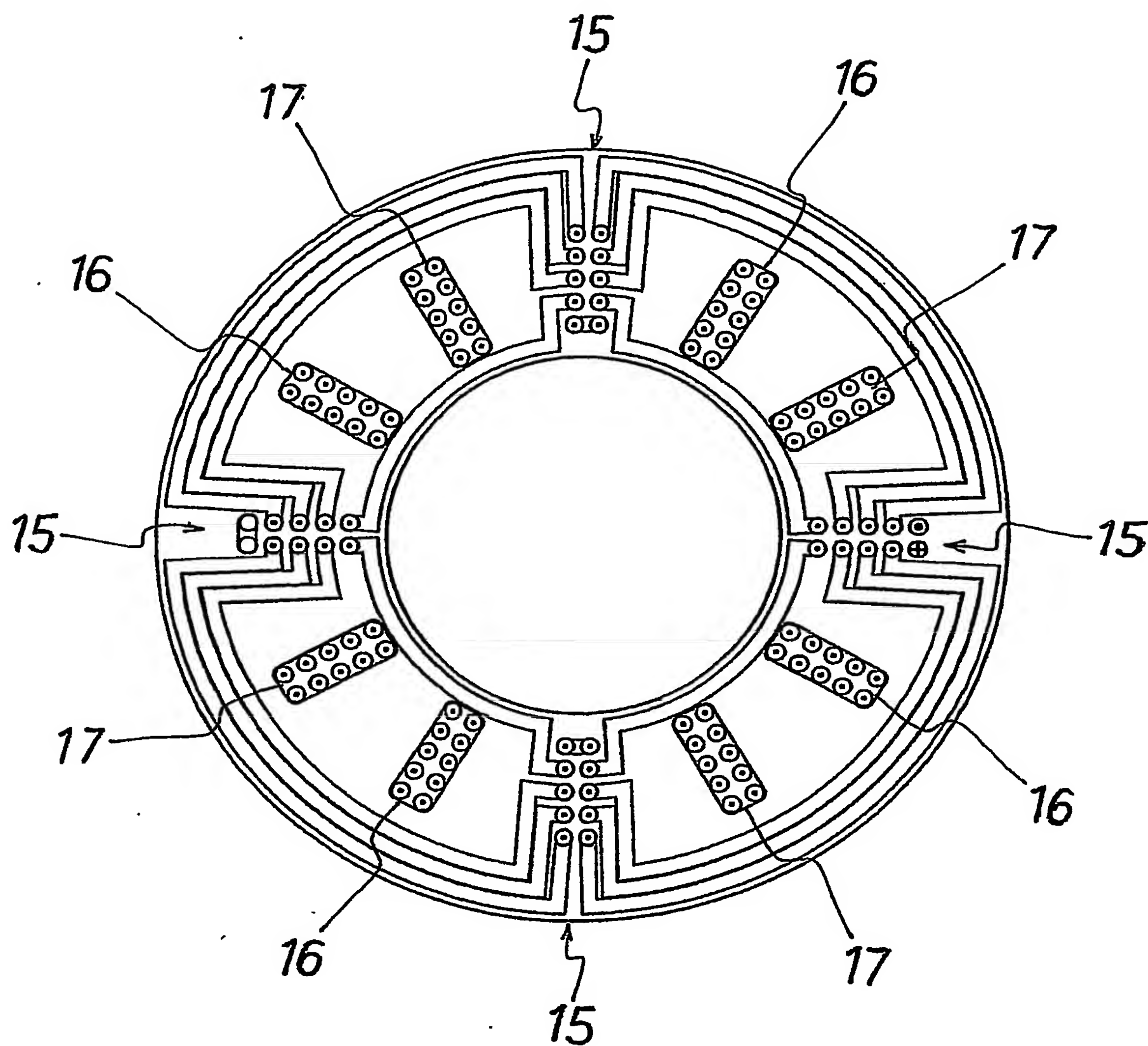
**Fig 2**

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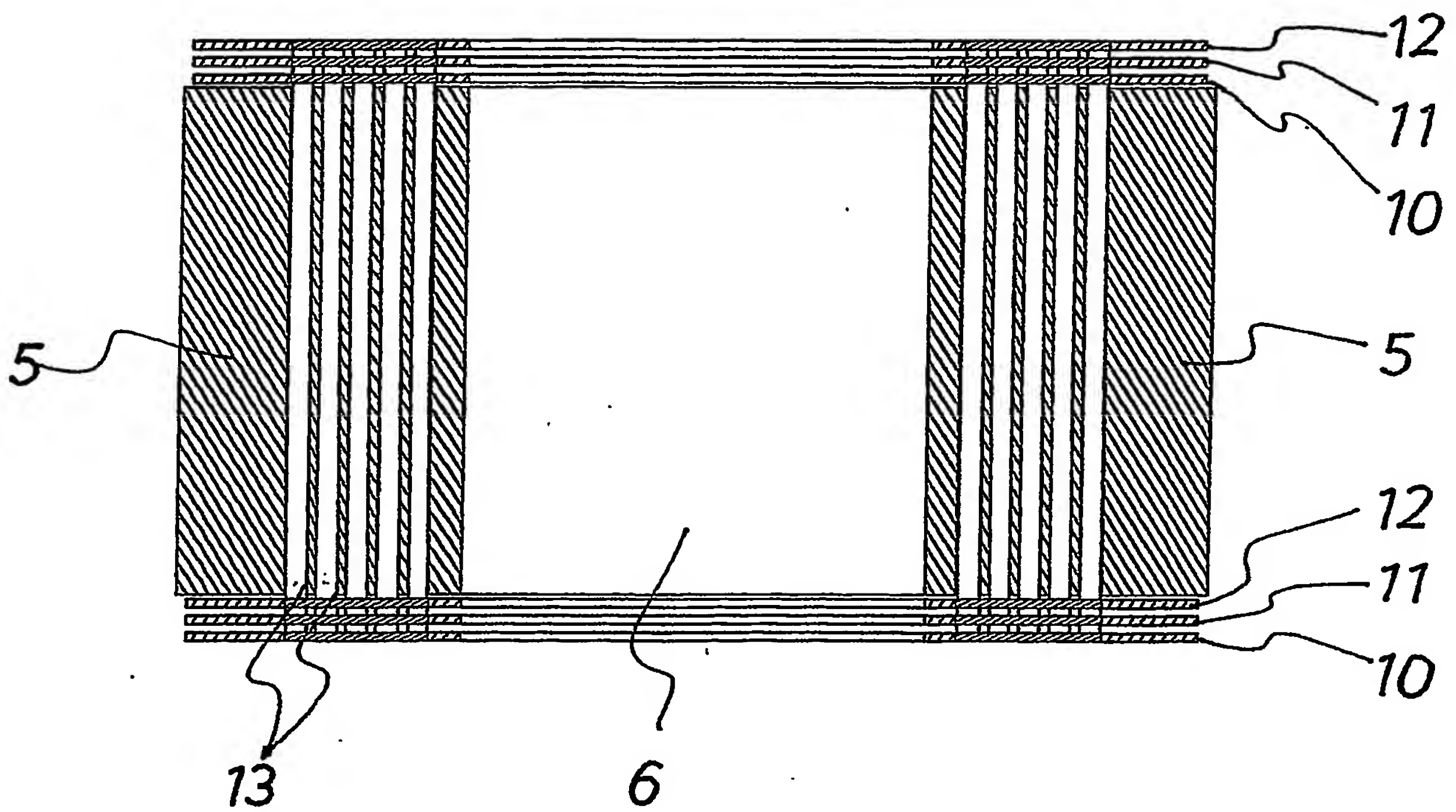
**Fig 3**

4/7



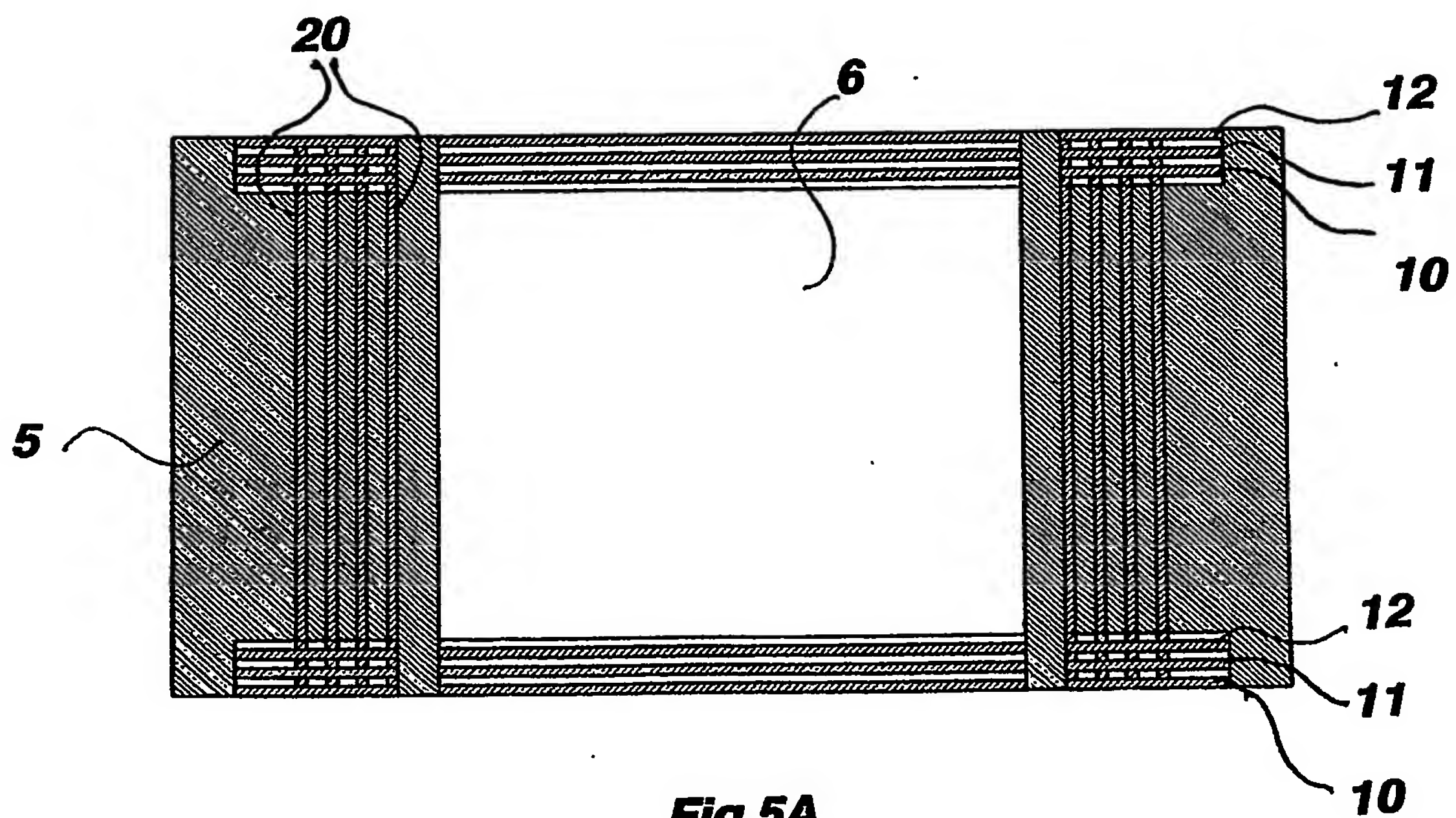
**Fig 4**

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**Fig 5**

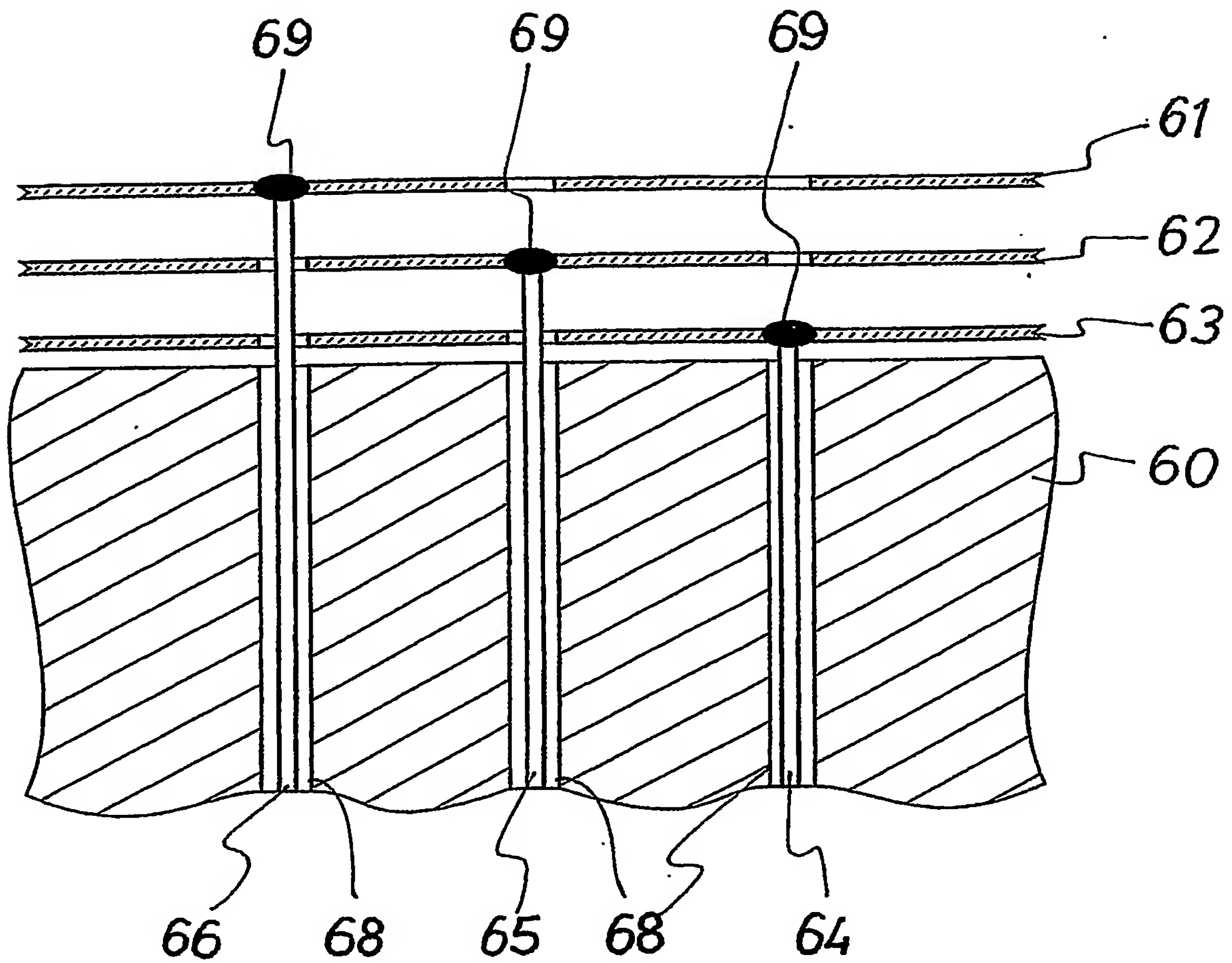
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**Fig 5A**



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**Fig 6**

**PATENT COOPERATION TREATY**  
**PCT**

REC'D 28 MAR 2006

WIPO

PCT

**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70):

Applicant's or agent's file reference 54844PCT	<b>FOR FURTHER ACTION</b>		See Form PCT/IPEA/416																								
International application No. PCT/AU2004/001601	International filing date (day/month/year) 19 November 2004	Priority date (day/month/year) 20 November 2003																									
International Patent Classification (IPC) or national classification and IPC  Int. Cl.  <div style="display: flex; justify-content: space-around;"><span><i>H02K 3/26</i> (2006.01)</span><span><i>H02K 15/085</i> (2006.01)</span></div>																											
Applicant  INTELLIGENT ELECTRIC MOTOR SOLUTIONS PTY LTD et al																											
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 4 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p style="margin-left: 20px;">a. <input checked="" type="checkbox"/> (sent to the applicant and to the International Bureau) a total of 15 sheets, as follows:</p> <div style="margin-left: 40px;"><p><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p><p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p></div> <p style="margin-left: 20px;">b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>																											
<p>4. This report contains indications relating to the following items:</p> <table style="width: 100%; border: none;"><tr><td style="width: 5%;"><input checked="" type="checkbox"/></td><td style="width: 15%;">Box No. I</td><td>Basis of the report</td></tr><tr><td><input type="checkbox"/></td><td>Box No. II</td><td>Priority</td></tr><tr><td><input type="checkbox"/></td><td>Box No. III</td><td>Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td></tr><tr><td><input type="checkbox"/></td><td>Box No. IV</td><td>Lack of unity of invention</td></tr><tr><td><input checked="" type="checkbox"/></td><td>Box No. V</td><td>Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</td></tr><tr><td><input type="checkbox"/></td><td>Box No. VI</td><td>Certain documents cited</td></tr><tr><td><input type="checkbox"/></td><td>Box No. VII</td><td>Certain defects in the international application</td></tr><tr><td><input type="checkbox"/></td><td>Box No. VIII</td><td>Certain observations on the international application</td></tr></table>				<input checked="" type="checkbox"/>	Box No. I	Basis of the report	<input type="checkbox"/>	Box No. II	Priority	<input type="checkbox"/>	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability	<input type="checkbox"/>	Box No. IV	Lack of unity of invention	<input checked="" type="checkbox"/>	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement	<input type="checkbox"/>	Box No. VI	Certain documents cited	<input type="checkbox"/>	Box No. VII	Certain defects in the international application	<input type="checkbox"/>	Box No. VIII	Certain observations on the international application
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<input type="checkbox"/>	Box No. VIII	Certain observations on the international application																									
Date of submission of the demand 8 September 2005		Date of completion of this report 17 March 2006																									
Name and mailing address of the IPEA/AU  AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929		Authorized Officer  <b>MANO RAMACHANDRAN</b> Telephone No. (02) 6283 2166																									

## Box No. I Basis of the report

With regard to the language, this report is based on:

☐ The international application in the language in which it was filed

☐ A translation of the international application into \_\_\_\_\_, which is the language of a translation furnished for the purposes of:

☐ international search (under Rules 12.3(a) and 23.1 (b))

☐ publication of the international application (under Rule 12.4(a))

☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

With regard to the elements of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

☐ the international application as originally filed/furnished

☒ the description:

pages 2-5 as originally filed/furnished

pages\* 1, 6-8 received by this Authority on 24 October 2005 with the letter of 24 October 2005

pages\* received by this Authority on with the letter of

☒ the claims:

pages as originally filed/furnished

pages\* as amended (together with any statement) under Article 19

pages\* 9,10 received by this Authority on 20 February 2006 with the letter of 20 February 2006

pages\* 11,12 received by this Authority on 24 October 2005 with the letter of 24 October 2005

☒ the drawings:

pages as originally filed/furnished

pages\* 1-7 received by this Authority on 24 October 2005 with the letter of 24 October 2005

pages\* received by this Authority on with the letter of

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

☐ The amendments have resulted in the cancellation of:

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/figs

☐ the sequence listing (*specify*):

☐ any table(s) related to the sequence listing (*specify*):

☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/figs

☐ the sequence listing (*specify*):

☐ any table(s) related to the sequence listing (*specify*):

*If item 4 applies, some or all of those sheets may be marked "superseded."*

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/AU2004/001601

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

## Statement

Novelty (N)	Claims 1-18,20	YES
	Claims 19,21	NO
Inventive step (IS)	Claims	YES
	Claims 1-21	NO
Industrial applicability (IA)	Claims 1-21	YES
	Claims	NO

## Citations and explanations (Rule 70.7)

D1: US 4115915 A

D2: US 3252027 A

D3: US 4947065 A

D4: WO 1995012912 A1

D5: US 6617747 B1

NOVELTY (N) claims 19, 21:

Each of the citations D1 and D2 discloses a method of constructing an electric machine by passing at least two electrically insulated wires or other elongate conductors through a respective one of at least two bores which pass through a magnetically inducible core and connecting at least one of the ends of each conductor by a bridging member as in claims 19 and 21. Please see D1: abstract, column 3, lines 39- 54, figs, D2: column 3, lines 18-55, fig 9,]. Hence the invention claimed in claims 19 and 21 is not considered to be novel.

None of the citations listed above discloses an electric machine including magnetically inducible core of a substantially isotropic material, elongated conductors disposed in the slots of the core connected by bridging members on either side of the core as in claims 1 and 18. Claims 2-17 appended to claim 1, claim additional features and hence the invention defined in claims 2-17 and 18, is considered to be novel.

INVENTIVE STEP (IS) Claims 1-21:

Claims 19, 21: As above.

Claims 1-18, 20:

Each of the citations D1, D2, discloses an electric machine including a magnetically inducible core having plurality of elongated bores, plurality of elongated electrical conductors passing through a respective bore, plurality of bridging members, each bridging member electrically connecting the corresponding elongated conductors in pairs by connecting the first ends of the elongate electrical conductors disposed on a first side of the core, the second ends of the elongate electrical conductors disposed on a second side of the core so as to form continuous individual multi-phase windings.

Continued

## Supplemental Box

case the space in any of the preceding boxes is not sufficient.

Continuation of Box V:

Referring to citation D1 : an electric machine [column 1, lines 50-54] including a magnetically inducible core [20] having a plurality of elongated bores [21], plurality of elongated electrical conductors [15s] passing through a respective bore, plurality of bridging members [15e], each bridging member electrically connects the elongated conductors in pairs by connecting the first ends of the elongate electrical conductors disposed on a first side of the core [19a], the second ends of the elongate electrical conductors disposed on a second side of the core [19c] so as to form continuous individual multi-phase windings [column 3, lines 1-6], the bridging member is a printed circuit board [column 3, lines 30-33], are as claimed.

Referring to citation D2: an electric machine [column 3, lines 12-18] including a magnetically inducible core [2] having a plurality of elongated bores [fig 9], plurality of elongated electrical conductors [16,17,18] passing through a respective bore, plurality of bridging members [10,11], each bridging member electrically connects the elongated conductors in pairs by connecting the first ends of the elongate electrical conductors disposed on a first side of the core [figs 7, 9 ], the second ends of the elongate electrical conductors disposed on a second side of the core [fig 9] so as to form continuous individual multi-phase windings [column 3, lines 23-31], are as claimed.

Each of the citations D3 to D5 discloses an electrical machine having a stator core formed of an isotropic material such as a soft magnetic composite material. Please see in D3: abstract, in D4: page 11, lines 24-28, in D5: abstract.

Hence when the disclosure of the citations D1 or D2 is combined with the disclosure of the citations D3 or D4 or D5, it would be obvious to a person skilled in the art, disclose all of the features of claims 1-9, 11-18 and 20.

Additional features of claim 10 not explicitly disclosed in the above citations merely amount to common general knowledge and does not involve an inventive step.

Hence the invention claimed in claims 1-18, and 20 is not considered to involve an inventive step.

**INDUSTRIAL APPLICABILITY (IA) claims 1-21:**

The invention claimed in claims 1-21 is industrially applicable.